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IMPROVISED PYROTECHNIC MIXTURES FOR GUERRILLA WARFARE APPLICATIONS

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PICATINNY ARSENAL
DOVER, NEW JERSEY

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IMPROVISED PYROTECHNIC MIXTURES FOR GUERRILLA WARFARE APPLICATIONS

by

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OBJECT

To develop, evaluate, and determine the feasibility of pyrotechnic formulations improvised from indigenous materials for incendiary and demolition purposes for tactical application in guerrilla warfare.

SUMMARY

A series of pyrotechnic formulations developed from readily available constituents for use in guerrilla warfare have been evaluated. The systems were tested under confinement provided by two test vehicles consisting of short sections of cast iron pipe, one having a 2-inch inside diameter and the other a 1-inch inside diameter. Both were threaded and sealed at both ends with caps, with either Laminac 4116 resin or Duco cement as the sealing compound. Initiation was accomplished by placing either commercial quickmatch or a J–2 blasting cap through a perforation in the top cap. Performance was graded in accordance with the system's capability of reacting completely and the degree of fragmentation of the test vehicle.

A number of systems, such as 90/10 potassium chlorate/petrolatum, 71/29 potassium nitrate/grains of wood, and 25/50/25 sodium nitrate/ammonium nitrate/sawdust, were found suitable for guerrilla warfare on the basis of field tests. Several systems developed primarily for incendiary applications, such as thermite (40/60 aluminum/iron oxide, with a magnesium charge) and 16/10/74 linseed oil/sulfur/sodium nitrate, were evaluated both in a can and in a cloth bag. The excellent performance of these compositions was determined by visual observation.

INTRODUCTION

An investigation has been conducted of various pyrotechnic systems improvised from indigenous materials. These systems contain a wide variety of materials, selected because they are considered to be available in urban areas, on farms, and in fields throughout the world. These compositions were designed for multipurpose capability for producing incendiary ignition and demolition effects in guerrilla warfare. Consequently, those systems formulated specifically for their demolition possibilities were tested and evaluated in a confined state using as test vehicles sections of both 2- and 1-inch inside diameter cast iron pipe sealed with caps (Figs 1 and 2, pp 14 and 15). The systems designed for incendiary ignition were tested in an unconfined state. Although more sophisticated and meaningful tests were available to evaluate the thermochemical properties of these systems, this initial study was primarily directed towards determining the feasibility of using such systems in incendiary applications. The criterion for acceptable performance for those compositions tested in a confined state was based on fragmentation of the cast iron pipe and the size of the fragments obtained. The incendiary systems were graded from observation of the heat generated by their functioning.

RESULTS

Of some 27 compositions formulated primarily for their demolition or detonation potential, 3 completely fragmented the test vehicle, 9 ruptured the vehicle or blew off the end caps, and 15 gave poor results such as no fragmentation (with unreacted powder remaining in the test vehicle), or rupturing of the test vehicle. These formulations and their performance characteristics are summarized in Tables 1 through 3 (pp 8 through 10).

The systems formulated for incendiary ignition (Table 4, p 11) exhibited excellent generation of heat on combustion.

Compositions containing aluminum and iron in various forms and grades of purity in combination with potassium perchlorate oxidant were tested and evaluated. These systems are listed in Tables 5 and 6 (pp 12 and 13). Some additional systems which were studied are also included in Table 6. The compositions containing aluminum (Table 5) all gave excellent test results, while the remainder did not perform acceptably. Of the systems listed in Table 6, only the 90/10 ammonium nitrate/dinitrobenzene and the 90/10 potassium chlorate/petrolatum gave excellent performance when tested.

DISCUSSION OF RESULTS

Some 29 different compositions were formulated initially for use in guerrilla warfare. These systems were prepared from constituents that were considered to be indigenous and would make good substitutes for chemical compounds and elements normally found in demolition and ignition systems. Consideration was also given to formulating these systems so that they could be used for many different purposes. Initial tests of the compositions were conducted primarily to observe the order of the reactions, if any, and to determine the feasibility of employing a 2.0-inch-ID cast iron pipe (Fig 1, p 14) as the test vehicle. These initial tests showed some promising results.

Test results summarized in Table 1 (p 8) showed that five of the systems tested (1, 3, 5, 8, and 9) exhibited a high order of reaction as indicated by their capability of fragmenting the test vehicles into large pieces. Compositions 4, 6, and 7 showed a low order of reaction in that they merely blew the caps off the test vehicle, while the remaining four systems (2, 10, 11, and 12) did not show any reaction. It should be noted that interpretation of the test results was based on visual observation. Further, the degree or order of reaction was correlated with the extent of fragmentation of the test vehicle and the size of the fragments obtained. Consequently, the evaluation of these systems was purely qualitative in nature.

Of the compositions listed in Table 2 (p 9), only systems 3, 4, and 6 gave an acceptable level of reaction. The remaining systems (1, 2, and 5) did not function well and were rejected.

Of the systems covered by Table 3 (p 10), only compositions 3 and 4 exhibited an excellent order of reaction and good performance as evidenced by fragmentation of the test vehicle into small pieces. The other formulations (1, 2, 5, 6, 7, and 9) reacted completely within the test vehicle, and in only a few cases were the systems even capable of blowing the caps off the test vehicle.

The systems which were formulated specifically for incendiary ignition (numbers 8 and 10, Table 4, p 11) had excellent flaming properties, accompanied by good heat generation for a substantial period of time. The test vehicles employed for evaluation of these systems, a cloth bag and a half-gallon can are indicative of the type of vehicles that can be utilized in the field for these systems. The results achieved also indicate that such

compositions can be loaded into almost any type of vehicle, depending on the specific application.

From the results of this initial test, it is apparent that a number of the compositions tested are suitable for the intended application in guerrilla warfare. The systems which were considered to be optimum were: 1, 3, 5, 8, and 9 in Table 1 (p 8); 3, 4, and 6 in Table 2 (p 9); and 3, 4, 8, and 10 in Tables 3 and 4 (pp 10 and 11). After the initial series of tests, it was decided to retest those systems which gave a low order reaction, using a U. S. Army J–2 blasting cap instead of the commercial quickmatch used as the initiator in the first test series. The use of the J–2 blasting cap eliminated the need for a first fire charge, which was required for the initiation of most of the systems in the first series. It was not considered necessary to conduct retests of the systems which gave good performance initially, since the use of a blasting cap would probably improve their performance. The systems which did not function in the first test series were not considered for retesting nor were those which contained ammonium nitrate as the principal constituent, since a booster charge would be required to detonate them.

Results obtained for compositions selected for retest indicated significant improvement in a number of the systems employing a J–2 blasting cap as initiator. Consequently, a number of additional compositions (6, 11, and 12 from Table 1; 1 from Table 2; and 5 and 7 from Table 3) were selected as being suitable for guerrilla warfare applications.

The program was continued with the study and evaluation of compositions containing metallic aluminum and iron in different forms and purities such as powder, turnings, and filings. This approach was considered to be a necessity, since the guerrilla in the field may not always find these metals in a form that is conducive to chemical reaction. These compositions were tested in the same type of vehicle used in the previous tests except that the inside diameter was decreased to 1 inch (Fig 2, p 15). The J–2 blasting cap was maintained as initiator. Results of the field tests showed that all the systems containing aluminum in combination with potassium perchlorate (Nos. 20, 21, 22, and 27) gave a high order reaction accompanied by detonation and complete fragmentation of the test vehicle.

irrespective of the form (or purity) of the metal (Tables 5 and 6, pp 12 and 13). Two additional systems were tested, one containing aluminum/ammonium perchlorate (No. 25), which gave excellent performance, and one containing aluminum/carbon tetrachloride (No. 19), which flashed and burned but did not detonate. The formulations combining iron filings or turnings with potassium perchlorate (Nos. 23 and 24) did not perform acceptably. This was also found to be true for the more purified form of iron powder (No. 14). Of the remaining compositions investigated, only two gave an acceptable performance level (high order reaction with detonation and complete fragmentation). These systems were composed of ammonium nitrate and coal (No. 16), and potassium chlorate and petrolatum (No. 18).

It should be noted that the sensitivity and performance of these systems varies with the purity, particle size, and quantity of the constituents. The substitution or addition of other agents affects their sensitivity and performance. In general, these systems should not be subjected to undue impact or friction. The level of reaction and/or performance of these compositions depends upon the type of confinement, degree of consolidation, and method of initiation. Since it is known that many of these compositions are hygroscopic, adequate measures should be taken to protect and store them under waterproof conditions.

CONCLUSIONS

A number of different types of systems have been evaluated which can be formulated from readily available indigenous materials. The test results for these systems indicate that they would be suitable for use in demolition and incendiary applications in guerrilla warfare. Compositions such as aluminum/potassium perchlorate, ammonium nitrate/coal, and potassium chlorate/petrolatum are typical examples of systems that can be easily formulated and used by the guerrilla fighter in the field.

RECOMMENDATIONS

The work summarized in this investigation was primarily directed towards establishing the feasibility of employing systems formulated from indigenous materials. It is believed that the feasibility of such systems has been established. It is recommended, however, that a more far-reaching program be undertaken in the near future. This program should include studies of common household materials such as flour, corn meal, spices, coffee, etc. In addition, it is recommended that more specific physico-chemical parameters, such as detonation rate, heat of reaction and/or heat of combustion, and ignition temperature be obtained for the systems evaluated.

EXPERIMENTAL PROCEDURE

Materials Used

The materials used in the formulations evaluated in this program represent the most impure grades obtainable. Certain of the constituents were brought in from the employees' homes, while other ingredients were waste materials from the carpenter's shop and heating plant at Picatinny. The only exceptions were the following materials:

Aluminum, atomized	Ammonium chloride
Aluminum, flaked	Iron powder
Sodium nitrate	Magnesium, ground
Potassium perchlorate	Ferrous sulfide
Sulfur flowers	Ferric oxide
Potassium nitrate	

It is considered that these ingredients would be readily available in homes, drug and hardware stores, and chemical supply houses in all areas of the world.

Blending

The compositions containing dry ingredients only were blended in accordance with Sequence of Operations PACU No. 5. Those containing an oil or liquid were blended in accordance with Sequence of Operations PACU No. 3.

Loading

The compositions were loaded by hand tamping into the test vehicle, using a wooden punch of the proper diameter.

Testing

The initial tests of these formulations (Tables 1, 2, and 3, pp 8, 9, and 10) were conducted in the 2.0-inch-inside-diameter cast iron test vehicle which was ignited by means of an igniter composition in combination with commercial quickmatch. The incendiary systems were initiated with commercial quickmatch only. Subsequent tests and retests of several

formulations (Tables 1, 2, 3, 5, and 6, pp 8, 9, 10, 12, and 13) were conducted in both the 2.0-inch- and the 1.0-inch-inside-diameter test vehicles. These formulations were initiated with an Army J–2 blasting cap, which was functioned electrically.

TABLE 1

Formulations for Demolition Applications – Phase 1

	Formulations											
	1	2	3	4	5	6	7	8	9	10	11	12
Ingredients												
Potassium nitrate, JAN–P–156A			70	74								
Sulfur, JAN–S–487			18		5							
Charcoal			6		10							
Coal				13								
Potassium perchlorate, PA–PD–254	60											
Sodium nitrate, PA–PD–495		45			60			25				
Grains of wood				13	5							
Animal dung (chicken)			6									
Ammonium chloride, CP grade		53										
Ammonium nitrate, JAN–A–175					20	90	75	50	30	100	94	92
Sodium carbonate, CP grade		2										
Aluminum, flaked, JAN–A–289	40					6			1			4
Formulation No. 4, Table 2									69			
Sawdust							7	25				
Ferrous sulfide, CP grade						4						
Calcium carbonate, CP grade							18					
Fuel oil												4
Kerosene											6	
Test Vehicle												
2-inch-ID cast iron pipe with nipples												
Charge weight, g	142.8	186.2	163.2	142.4	190.5	146.3	163.0	127.0	174.6	139.8	122.2	119.6
First fire charge, PP–4, g			5	5	5	5	5	5	5	5	5	5
Type of performance obtained	HO[1]	NF[2]	HO	LO[3]	HO	LO[4]	LO	HO	HO	NF[4]	NF[4]	NF[4]

[1] HO = high order.

[2] NF = no fire.

[3] LO = low order.

[4] Functioned high order using J–2 blasting cap as initiator.

TABLE 2

More Formulations for Demolition Applications – Phase 1

	Formulations					
	1	2	3	4	5	6
Ingredients						
Potassium nitrate, JAN–P–156A	74	74			84	71
Sulfur, JAN–S–487	10	10	10	10		
Charcoal	16		16	16	16	
Coal		16				
Potassium perchlorate, PA–PD–254				74		
Sodium nitrate, PA–PD–495			74			
Grains of wood						29
Test Vehicle						
2-inch-ID cast iron pipe with nipples						
Charge weight, g	148.5	163.0	162.5	185.0	163.0	110.9
First fire composition, PP–4, g			10.0			7.0
Type of performance obtained	LO[1,2]	LO	HO[3]	HO	LO	HO

[1]LO = low order.

[2]Functioned high order using J–2 blasting cap as initiator.

[3]HO = high order.

TABLE 3

Further Formulations for Demolition Applications – Phase 1

	Formulations							
	1	2	3	4	5	6	7	9
Ingredients								
Potassium perchlorate, PA–PD–254					70	75		
Aluminum, flaked, JAN–A–289			20				10	
Propellant powder, PP–5	80	90	80	80			90	90
Magnesium, ground, JAN–M–382A				20				10
Iron oxide powder (Fe_2O_3), JAN–1–706	20	10			30	25		
Test Vehicle								
2-inch-ID cast iron pipe with nipples								
Charge weight, g	200.0	181.5	133.3	167.7	279.3	274.0	137.8	171.7
Type of performance obtained	LO[1]	LO	HO[2]	HO	LO[3]	LO	LO[3]	LO

[1]LO = low order.

[2]HO = high order.

[3]Functioned high order using J–2 blasting cap as initiator.

TABLE 4

Incendiary-Ignition Systems

	Formulations	
	8[1]	10
Ingredients		
Linseed oil		16
Sulfur, JAN–S–487		10
Sodium nitrate, PA–PD–495		74
Aluminum, flaked, JAN–A–289	40 (center charge)	
Iron oxide powder (Fe_2O_3), JAN–1–706	60 (center charge)	
Potassium chlorate/sugar (EP–13)	100 (center tube and top charge)	
Magnesium, ground	100 (bottom charge)	
Test Vehicle		
½-gallon can with center tube		
Cloth bag		
Charge weight, g	200	1000
Test Results		
High order combustion	Yes	Yes
Complete combustion of composition	Yes	Yes

Comments: Composition 8 reacted vigorously and gave off a large amount of heat, as did Composition 10.

[1] The center tube contained 5.0 grams of 75/25 potassium chlorate/sugar (EP–13); 190 grams of EP–13 was placed in a paper bag in the form of a ring on top of the 40/60 Al/Fe_2O_3 charge which covered a 200-g charge of ground magnesium at the bottom of the can.

TABLE 5

Formulations for Demolition Applications – Phase 2

	19	20	21	22	23	24	25	26	27
Ingredients									
Aluminum, atomized, MIL–P–14067, 98.75% free metal							37.9		34
Potassium perchlorate, PA–PD–254		60	60	60	48	48			66
Aluminum filings, g	60			40					
Carbon tetrachloride, cc	45								
Aluminum turnings		40							
Aluminum turnings, degreased			40						
Iron filings					52				
Iron turnings						52			
Ammonium perchlorate, JAN–A–192							62.1		
Potassium chlorate, PA–PD–288								66.7	
Sugar								22.2	
Paraffin wax								11.1	
Test Vehicle									
1.0-inch-ID cast iron pipe with nipples									
Charge weight, g	28.8	32.5	39.7	46.1	91.6	79.6	33.2	–	47.0
Type of performance obtained	FB[1]	HO[2]	HO	HO	LO[3]	LO	HO	LO	HO

[1] Flashed and burned.

[2] HO = high order.

[3] LO = low order.

TABLE 6

More Formulations for Demolition Applications – Phase 2

	Formulations				
	14	15	16	17	18
Ingredients					
Potassium perchlorate, PA–PD–254	48				
Iron powder, CP grade	52				
Ammonium nitrate, JAN–A–175		87	90	90	
Dinitrobenzene		13			
Coal			10		
Charcoal				10	
Potassium chlorate, PA–PD–288					90
Petrolatum					10
Test Vehicle					
1.0-inch-ID cast iron pipe with nipples					
Charge weight, g	65.0	27.5	27.0	30.0	30.0
Type of performance obtained	LO[1]	LO	HO[2]	LO	HO

[1] LO = low order.

[2] HO = high order.

Fig 1 Two-inch-diameter test vehicle

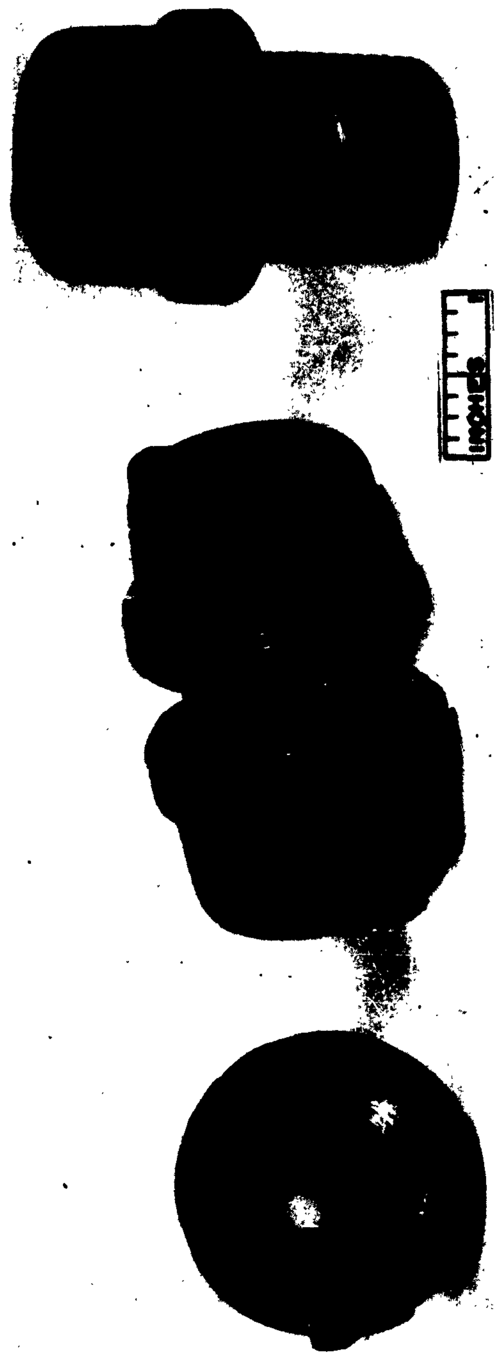

Fig 2 One-inch-diameter test vehicle

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2. Guerrilla warfare
3. Incendiary mixtures

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III. Title

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Technical Memorandum 1280, April 1964, 17 pp, tables, figures, AMCMS No. 5561.12.46802, DA Proj 1A542703–D–346. Unclassified report.

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2. Guerrilla warfare
3. Incendiary mixtures

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II. Kaye, S. M.
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